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Materiel Test Procedure 6-2-063
Electronic Proving Ground

U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

COMPUTER, DIGITAL, FIELD ARTILLERY AND PROGRAMS FOR ARTILLERY APPLICATIONS

1. OBJECTIVE

The objective of this document is to prescribe the engineering test procedures required to determine the technical performance and characteristics of field artillery digital computers relative to the requirements of applicable Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), Technical Characteristics (TC), or other appropriate documentation, and determining their suitability for an intended use.

2. BACKGROUND

The field artillery digital computer, such as gun direction computer M18 (FADAC), was developed primarily to compute accurate firing data, rapidly, for artillery weapons from data inputs defining target location, weapon location, and prevailing conditions of equipment, material and weather.

The principle advantage gained in using a digital computer to solve the gunnery problem is a significant improvement in the accuracy and flexibility in the delivery of surprise fires. This is possible because the final computer solution can be based upon an electronic simulation of the trajectory using existing ballistic conditions, thereby resulting in a higher probability that the first actual fired round will be on target.

Although designed for a specific use in the field, the field artillery digital computer can be used as a tactical digital computer for such other applications as survey computations, weapons-effects analysis, sound and flash ranging, triangulation in photogrammetry and meteorological data reduction. Limited only by the size of its memory unit (8,192 words for FADAC), the computer can also be programmed for general military or non-military usage. A simplified block diagram of the digital computer is shown in Figure 1.

The importance of the equipment mission indicates the need for engineering tests to ensure that the commodity meets applicable requirements and has the specialized characteristics for its intended use.

3. REQUIRED EQUIPMENT

a. Bench test facilities, including a 3-phase, 4-wire, 400 hertz, 120/208 volt power source.
b. Memory loading unit (Reproducer, Signal Data AN/GSQ-14).
c. Tapes, prepunched programs and data, as required.
d. Frequency/time standard.
e. Oscilloscope.
f. Camera, with oscilloscope adapter.
g. Test set, computer logic unit (AN/GSM-70), as required for fault diagnosis.

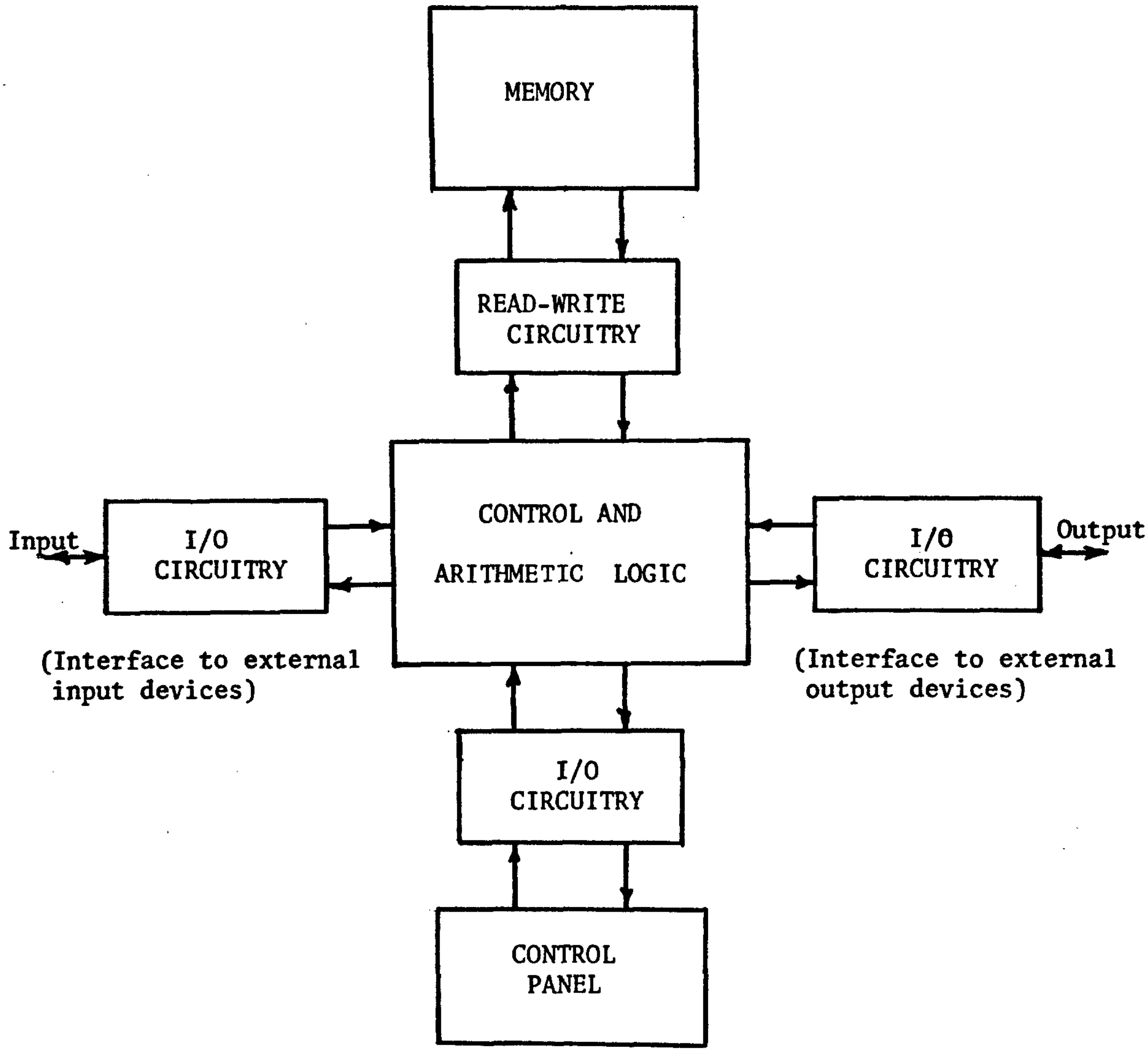

Figure 1. Block Diagram of Digital Computer

4. REFERENCES

A. Army Technical Manual TM 9-1220-221-10, Computer, Gun Direction M-18 - Operators Manual.
B. TM 9-1220-221-20/1, Computer, Gun Direction, M18 - Organization Maintenance Manual.
C. Army Field Manual FM 6-3-1, Operation of the Gun Direction Computer M18 - Cannon Application.
D. TM 9-1290-326-12, Reproducer, Signal Data AN/GSQ-64, Operators and Organizational Maintenance Manual.
E. TM 9-4931-204-12, Test Set, Computer Logic Unit, AN/GSM-70.
F. Price, T. J., Computer, Gun Direction M18 (FADAC) Applications Manual, Technical Note TN-1119, U. S. Army Frankford Arsenal, Philadelphia, Pa., May 1967 (AD 664 137).
G. Farkas, L. L., Electronic Testing, McGraw-Hill, New York, 1966.
H. MTP 6-2-507, Safety.

5. SCOPE

5.1 SUMMARY

5.1.1 Technical Characteristics

The specific commodity tests to be performed are divided into component and system tests. These tests are given as follows:

a. Component Tests

1) Timing Circuits Test - The objective of this subtest is to determine the characteristics of critical timing signals which control the operations within the synchronous digital computer.
2) Real-Time Clock Test - The objective of this subtest is to determine the accuracy of the computer real-time clock and elapsed time indicator.

b. System Tests.

1) Check-Out Routine - The objective of this subtest is to ensure that the test item is operational, that is, it will function in accordance with its designed logic and control characteristics.
2) Sample-Problem Program - The objective of this subtest is to determine the performance capability of the test item with applicable software to solve sample field artillery problems with regard to accuracy and time required.

5.1.2 Common Engineering Tests

The following Common Engineering Tests, applicable to these commodities, are not included in this MTP:

a. MTP 6-2-500, Physical Characteristics
b. MTP 6-2-502, Human Factors Engineering

c. MTP 6-2-504, Design for Maintainability.
d. MTP 6-2-508, Electromagnetic Vulnerability.
e. MTP 6-2-509, Electromagnetic Compatibility.
f. MTP 6-2-514, Electrical Power Requirements.
g. MTP 6-2-516, Adequacy of Shelter and Van Mounted Lighting, Ventilation, Air Conditioning and Heating Equipment.
h. MTP 6-2-520, Transportability of Communication, Surveillance and Electronic Equipment.
i. MTP 6-2-530, Altitude and Temperature Altitude Test.
j. MTP 6-2-531, Temperature Test.
k. MTP 6-2-532, Sunshine Test.
l. MTP 6-2-533, Rain Test.
m. MTP 6-2-534, Humidity Test.
n. MTP 6-2-535, Fungus Test.
o. MTP 6-2-536, Salt Fog Test.
p. MTP 6-2-537, Dust Test.
q. MTP 6-2-538, Explosive Atmosphere Test.
r. MTP 6-2-539, Immersion Test.
s. MTP 6-2-540, Vibration Test.
t. MTP 6-2-541, Shock Test.

5.2 LIMITATIONS

This document excludes testing of data acquisition equipment and of firing units which would interface with the commodity. It also excludes determination of load or throughput capability.

6. PROCEDURES

6.1 PREPARATION FOR TEST

a. Select test equipment ideally having an accuracy of at least ten orders of magnitude greater than that afforded by the item under test, that is in keeping with the state-of-the-art, and whose calibration is certified in accordance with Department of the Army Regulations to assure traceability to the National Bureau of Standards.

b. Record the following information:

1) Nomenclature, serial number(s), manufacturer's name, and function of the item(s) under test.
2) Nomenclature, serial number, accuracy tolerance, calibration requirements, and last date calibrated of the test equipment selected for the tests.

c. Ensure that all test personnel are familiar with the required technical and operational characteristics of the item under test, such as stipulated in Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), and Technical Characteristics (TC).

d. Review all instructional material issued with the test item by the manufacturer, contractor, or government, as well as reports of previous similar tests conducted on the same types of equipment, and familiarize all test per-

sonnel with the contents of such documents. These documents shall be kept readily available for reference.

e. Ensure that the following software (see Appendix A) is readily available, or prepared, as applicable:

1) Check-out routine tape (if self-test routine is not built-in).
2) Applicable program (solution-instruction) tapes, and sample field artillery problems with input data and standard solutions.

f. Prepare adequate safety precautions to provide safety for personnel and equipment, and ensure that all safety SOP's are observed throughout the test and that the item has successfully completed the examination prescribed in MTP 6-2-507, Safety.

g. Prepare record forms for systematic entry of data, chronology of test, and analysis in final evaluation of the test item.

h. Thoroughly inspect the test item for obvious physical and electrical defects such as cracked or broken parts. loose connections, bare or broken wires, loose assemblies, bent critical parts, and corroded plugs or jacks. Check for continuity of wire terminations to ensure that wiring is connected to the proper terminals, and that no damage will result when power is applied. All defects shall be noted and corrected before proceeding with the test.

i. Prior to beginning any subtest, verify correct power source, necessary test instrumentation and inter-connection cabling, and that the equipment is aligned, if necessary, as specified in the pertinent operating instructions to ensure, insofar as possible, it represents an average equipment in normal operating condition.

6.2 TEST CONDUCT

NOTE: Modification of these procedures shall be made as required by technical design of the item under test and availability of test equipment, but only to the extent that such modified procedures will not affect the validity of the test results.

6.2.1 Component Tests

6.2.1.1 Timing Circuit Test

a. Connect an oscilloscope to each of the computer timing signal circuits and determine the frequency, amplitude, and pulse-time width as applicable to each signal. The following are typical:

1) Clock oscillator signal.
2) Basic clock pulse.
3) Timing pulse (multiple period of clock pulse).
4) Cycle pulse.

NOTE: Since the basic clock pulse width may vary from a fraction of a microsecond to several milliseconds for different computers, an oscilloscope with an adequate frequency response must be selected for the particular item under test.

b. Photograph each signal with an oscilloscope-adapted camera, annotate each photograph with respect to test point and applicable control settings, and record the following:

1) Frequency (hertz, or pulses per second).
2) Amplitude (volt).
3) Pulse-time width (second).

6.2.1.2 Real-time Clock Test

a. Using an appropriate frequency/time standard based upon requirements for the computer clock timing resolution and accuracy, determine appropriate time intervals with the real-time clock or elapsed-time indicator, and with the time standard.

b. Record the following:

1) Real-time clock interval (second).
2) Standard time interval (second).

6.2.2 <u>System Tests</u>

6.2.2.1 Check-out Routine

6.2.2.1.1 Manual - Determine the operability of the computer manual logic and controls as follows:

a. Apply power to the test item and perform the series of manual tests using the control panels in accordance with the operating instructions of the particular computer under test.

NOTE: This will generally involve testing single commands to ensure satisfactory performance of each.

b. Record errors, malfunctions or difficulties encountered.

6.2.2.1.2 Programmed - Determine the operability of the computer programmed logic and controls as follows:

a. Enter a taped checkout routine into the permanent storage channels of the computer memory utilizing an input device such as Signal Data Reproducer, AN/GSQ-64.

b. Start the programmed check-out operation in accordance with the operating procedures for the computer under test.

c. Record the following:

1) Description of any errors (parity, overflow).
2) Malfunctions or difficulties encountered.
3) Successful or unsuccessful completion.
4) Time for successful normal check-out (seconds).

d. Repeat Steps (a) (b) and (c) above, except momentarily switch-off

power to the test item during Step (b). Then repeat Steps (b) and (c) and record whether the check-out routine has been retained in permanent storage channels.

e. Enter a taped check-out routine into the computer as outlined in Step (a) above, switch the appropriate control to "marginal" test, and repeat Steps (b) and (c) above.

6.2.2.2 Sample-problem Program

a. Utilizing an input device such as Signal Data Reproducer AN/GSQ-64, enter a taped program containing computer instructions for the solution of a sample field artillery problem into the permanent storage channels of the computer memory unit. Determine and record the entry time.

b. Verify the program entered in the computer memory in accordance with the particular equipment operation procedures (e.g., as specified by Section IV of FM 6-3-1). Determine and record verification time.

c. Enter the input data necessary for solution of the problem. Determine and record data entry time.

d. Operate the computer under test in accordance with normal operating procedures to obtain a solution to the sample problem. (e.g., as specified by Appendix D of FM 6-3-1). Determine and record problem solution time.

e. Record problem solutions, detected errors, and description of equipment malfunctions which occur during the test run.

6.3 TEST DATA

6.3.1 Preparation for Test

Data to be recorded prior to testing shall include but not be limited to:

a. Nomenclature, serial number(s), manufacturer's name, and function of the item(s) under test.

b. Nomenclature, serial number, accuracy tolerance, calibration requirements, and last date calibrated of the test equipment selected for the tests.

c. Damages to the test item(s) incurred during transit and/or manufacturing defects.

6.3.2 Test Conduct

Data to be recorded in addition to specific instructions listed below for each sub-test shall include:

a. A block diagram of the test setup employed in each specified test. The block diagram shall identify by model and serial number, all test equipment and interconnections (cable lengths, connectors, attenuators, etc.) and indicate control and dial settings where necessary.

b. Photographs or motion pictures (black and white or color), sketches, charts, graphs, or other pictorial or graphic presentation which will support test results or conclusions.

c. An engineering logbook containing, in chronological order, pertinent remarks and observations which would aid in a subsequent analysis of the test data. This information may consist of descriptions of equipment or com-

ponents, and functions and deficiencies, as well as theoretical estimations, mathematical calculations, test conditions, intermittent or catastrophic failures, test parameters, etc., that were obtained during the test.

d. Test item sample size (number of measurement repetitions).
e. Instrumentation or measurement system mean error stated accuracy.

6.3.2.1 Component Tests

6.3.2.1.1 Timing Circuit Test

a. Record the following:

1) Frequency (hertz, or pulses per second).
2) Amplitude (volt).
3) Pulse-time width (second).

b. Retain oscilloscope signal trace photographs, suitably identified with respect to test point and control settings.

6.3.2.1.2 Real-time Clock Test

Record the following:

a. Clock time interval (second).
b. Standard time interval (second).

6.3.2.2 System Tests

6.3.2.2.1 Check-out Routine

Record the following:

a. Note of "successful" or "unsuccessful" completion of check-out routine for the following test conditions:

1) Normal checkout.
2) Normal checkout with momentary power switch-off. Note whether checkout routine has been retained in permanent storage channel.
3) Checkout under "marginal" conditions.

b. Description of any errors (parity, overflow), difficulties encountered, and malfunctions which occur during test runs.
c. Time for successful normal checkout (second).

6.3.2.2.2 Sample-problem Program

Record the following:

a. Description of sample field artillery problem; input data; and standard solution.

b. Taped program entry time (second).
c. Program verification time (second).
d. Input data entry time (second).
e. Computer execution time (second).
f. Computer solution.
g. Description of any errors (parity, overflow) and malfunctions which occur during test run.

6.4 DATA REDUCTION AND PRESENTATION

Processing of raw test data shall, in general, consist of organizing, marking for correlation and identification, and grouping the test data according to sub-test title. Test criteria or test item specifications shall be noted on the test data presentation to facilitate analysis and comparison. Where necessary, test data measurements shall be converted to be compatible with units given by test criteria or specifications.

In addition to the reduction and presentation of individual subtest data, as outlined in succeeding paragraphs, environmental or meteorological data shall be presented to include:

a. Temperature (degrees F).
b. Relative humidity (percent).
c. Atmospheric pressure (inches of hg).

6.4.1 Component Tests

6.4.1.1 Timing Circuits Test

Timing circuit signal data to be presented shall include the following as applicable:

a. Frequency (hertz, or pulses per second).
b. Amplitude (volt).
c. Pulse-time (second).

6.4.1.2 Real-time Clock Test

Real-time clock test data to be presented shall be the time error (second), or difference between clock-time and standard-time.

6.4.2 System Tests

6.4.2.1 Check-out Routine

Check-out routine test data to be presented shall include the following:

a. Statement of "successful" or "unsuccessful" completion of check-out for the following conditions:

(1) Normal routine.
(2) Normal routine with momentary power switch-off. Include statement as to whether program in permanent storage channel was "retained".
(3) Check-out under "marginal" test conditions.

b. Description of any errors (parity, overflow) and of malfunctions which occur during test runs.

c. Time (second) for successful normal check-out routine.

6.4.2.2 Sample-problem Program

Sample-problem program test data to be presented shall include the following:

a. Description of sample field artillery problem; input data; and standard solution.

b. Taped program entry time (second).

c. Program verification time (second).

d. Input data entry time (second)

e. Execution time (second).

f. Solution error, or difference between computer and standard solutions.

g. Description of errors (parity, overflow) and of malfunctions which occur during test runs.

GLOSSARY

Arithmetic Unit: Section of a digital computer which contains the circuits that perform arithmetic and logic (comparing) operations.
Clock: (1) Master timing device used to provide the basic sequencing pulses to operate a synchronous computer. (2) Register that automatically records the progress of real time.
Control Unit: Section of a digital computer which contains the circuits that effect the retrieval of instructions in proper sequence, the interpretation of each instruction, and the application of the proper signals to the arithmetic unit and other parts in accordance with this interpretation.
Input/Output (I/O): General term for the equipment used to communicate with a computer, and the data involved in the communication.
Input Unit: The device or collective set of devices used for transferring data into a digital computer or other equipment.
Memory Unit: The device or section of a digital computer into which data can be entered, in which it can be held, and from which it can be retrieved at a later time. Also called "storage" unit.
Output Unit: The device or collective set of devices used for transferring information out of a digital computer or other equipment.
Overflow: Error condition which arises when the result of an arithmetic operation exceeds the capacity of the number of representation in a digital computer, or the carry digit which results from this condition.
Parity: In a digital computer, the use of a self-checking code employing binary digits in which the total number of 1's or 0's in each permissable code expression is always even or always odd.
Parity Bit: Additional bit used at the end of a computer word to determine either the evenness or oddness of a number.
Permanent Memory: In digital computers, a storage channel or device for keeping data intact when the computer has been shut down.
Word: A sequence of bits or characters treated as a unit and capable of being stored in one computer location.

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APPENDIX A

TEST PROGRAMS FOR DIGITAL COMPUTERS

Test programs for digital computers are generally one of two types - the diagnostic program or the sample-problem program.

Diagnostic Program

A diagnostic program includes the features that are found in what are commonly called check-out routines and fault-location routines. The function of a check-out routine is to verify that the machine is operating properly. Some of them give no indication of the general nature or location of a fault if one is detected. The function of the fault-location routine is exactly as its name indicates.

The distinction between "diagnostic program" and "check-out routine" is primarily in their basic purpose rather than in their organization and operation. A question may arise when the factor of resolution in the fault-location process is considered. For example, a magnetic tape routine that fails with the gross indication that channel "three" failed has certainly accomplished something in the area of fault-location although a diagnostic programmer may argue that the information is of little value. The "pure" check-out routine might be expected to have only two outcomes or indications "O.K." or "Error". However, any additional information obtained, such as which part of the check-out routine detected the error does have some fault-location value and thus diagnostic value.

In general, check-out routines can be defined as those programs whose primary purpose is the detection of faults. If there are pre-planned procedures or steps to aid in fault location, specified for each fault detected, then the entire routine is classed as a diagnostic program.

The general organization of a complete diagnostic program including the manual procedures necessary at the beginning of a test is indicated in Figure A-1. The series of test routines shown down the column labeled "Check-Out Routines" represents the desired route for the program to follow. By themselves these test routines are normally referred to by the indicated name. When included in a complete diagnostic program, they are sometimes given the name "go path".

A good diagnostic program serves several purposes.

(1) It can be used to verify the "fault-free condition" of the system.
(2) If a failure is detected during routine check-out the diagnostic can be used to identify the replaceable element that contains the failure.
(3) After the defective element has been replaced, the diagnostic can be used to verify that the machine is then fault-free.

The expression "fault-free" condition must be used with care in describ-

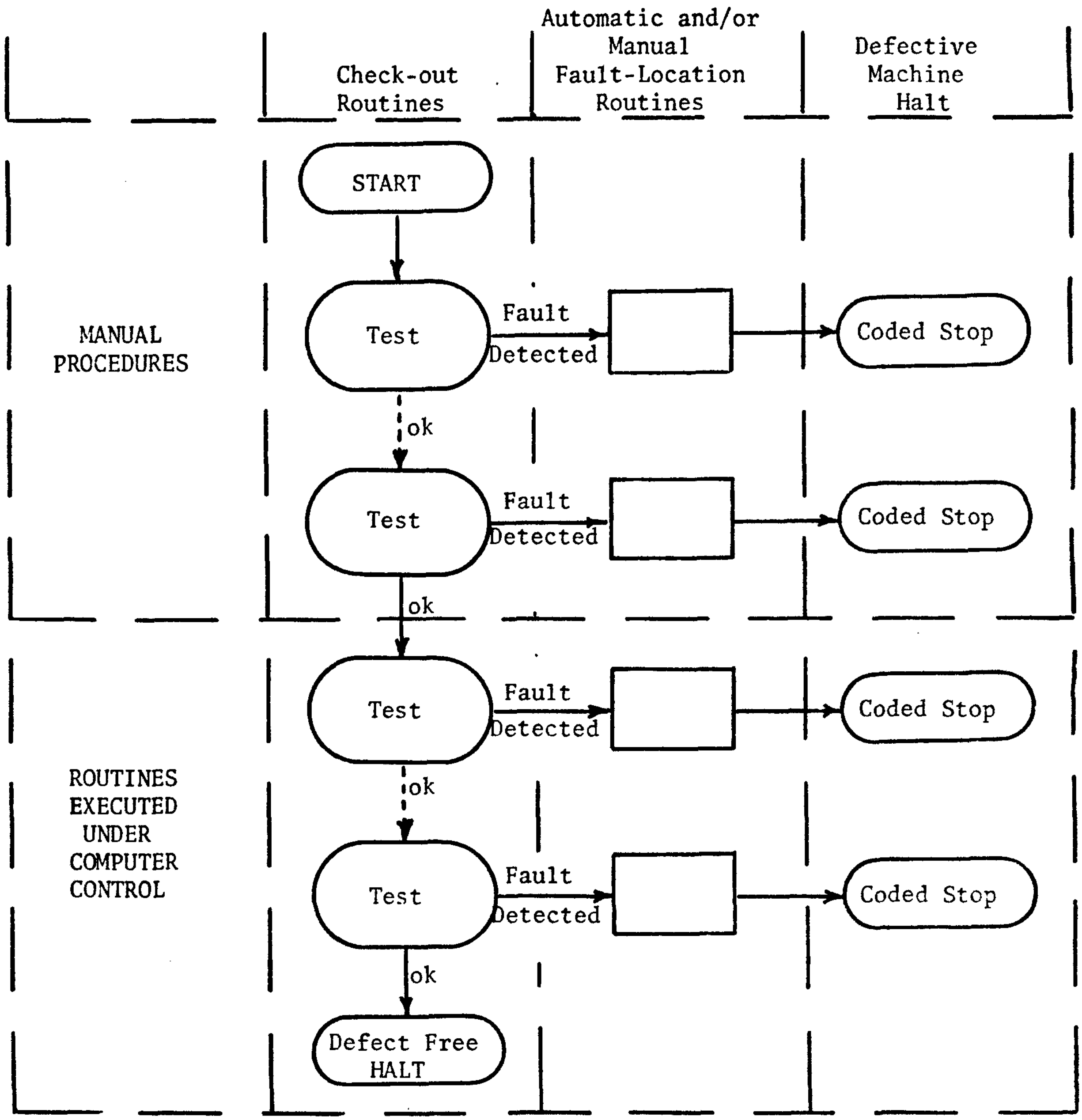

Figure A-1. General Organization of Diagnostic Procedures

ing the operation of a diagnostic program. The quality of the program is the key factor, for if the machine successfully passes all the tests in the diagnostic, then actually all that can be said is that it performed these tests correctly - not that it is completely fault-free.

As indicated in Figure A-1, a diagnostic program normally performs a series of tests to check-out various sections of hardware, and based upon the results of those tests either continues in the check-out mode or branches to a fault location routine if an error has been detected, finally arriving at a coded halt which, in association with a "dictionary" or similar form of documentation, indicates a replaceable unit in which a faulty element is located.

In preparing such a program it is essential to make assumptions as to the number and types of faults which may occur in a given machine. The program consists of a series of first manual and then programmed tests from whose results inferences are drawn as to the conditions of various hardware elements. The tests which are necessary can be identified only after a thorough study of the logical organization of the machine and the details of the hardware implementations of that logic. A complete diagnostic program must execute tests which verify that every signal functions properly - it is either active or inactive as specified by the design logic.

The general method followed during the execution of the check-out routine is that only previously checked-out portions are used to examine the operation of a new section. This means that when a fault is detected it is known to be somewhere in the "new section" and the program transfers to a fault-location routine to resolve its location. It is usually assumed that only a single fault exists in the machine so it is then possible to rely on the proper operation of all of the machine except this "new section" to aid in the fault location procedures.

During the manual check-out routines there are normally no assumptions made. The purpose of these routines is to validate the assumption made during the automatic check-out routines that the machine is "breathing", that is, the input, the memory, and the control unit are operative at least to the degree that a program can be placed in memory and that the simplest instruction can be executed without causing the machine to "hang-up".

The above discussion on checking-out or verifying the failure condition of the machine and locating the failure might give the impression that the actual components or at least the logic elements are tested in some manner similar to using a voltmeter to check a voltage, or an ohmmeter to check a resistor or diode. This is certainly not done if for no other reason than that the time required would be prohibitive. What is done is that the ability of a computer is used to compare the value of a signal obtained during a test run against a control value thereby permitting inferences to be drawn as to the condition of the hardware that produced the signal. During check-out, the control value would be a standard value or that obtained with a machine known to be defect free. During the execution of fault-location routines the control values may be those associated with the different failures possible.

The important point is that the signals in the computer are checked-out, not the hardware itself. Since this is the situation, it is usually not possible to determine whether the failure occurred in signal transmission, or signal reception without making manual tests with test instruments or using substitutional procedures.

A problem area in the preparation of diagnostic programs exists for input-output peripheral equipment. This problem is the result of the length of the diagnosible paths associated with the input-output. To perform an automatic check of such input-output devices as paper tape reader and paper tape punch, the procedure would probably have to be to punch an output tape, then place the tape in the reader to be checked for accuracy. Even if an error is detected, it is possible that it might have occurred at any point along a relatively long signal path through the computer. Unfortunately this is just about the best that can be done. Input/output device tests are usually not diagnostic in nature.

Sample-Problem Program

A sample-problem program is essentially an application-oriented approach to testing of the digital computer under actual operating conditions. With the availability of proven software, for example, program tapes containing instructions for solution of specific problems, of complete and accurate input data, and of standard known solutions, the computer can be operated under normal procedures to solve a representative problem or set of representative problems. Performance can then be determined in terms of program execution times and number and type of detected errors.